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Research Trends in Medical Physics: A Global Perspective

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Abstract

The paper presents an analysis of 11181 global publications in medical physics, indexed in Web of science database during 2000-2013; the average number of publications published per year was 798.64. Out of 11181 publications, maximum of 5014 (44.84%) publications have been contributed by mega authors, followed by multi authors with 3588 (32.09%) publications. The value of co authorship index for mega authored publications is the highest. The highest value of collaboration coefficient is 0.67 in 2013. The Degree of collaboration of publications of the medical physics is 0.96. Hendee, W R, Medical college Wisconsin, USA is the most productive author contributing 57 publications followed by Levin, C S, Stanford university school of medicine, USA with 52 publications and Yanagida, T, University of Tokyo, Japan with 51 publications. USA had the highest share (32.43%) of publications followed by Germany with 10.56% publications, Japan with 9.19% publications, and UK with 7.74% publications, and Italy with 7.47% publications and China with 5.11% publications. Among the prolific institutions, Istituto nazionale di fisica nucleare, Frascati, Italy had the highest (2.95%) publications followed by European organization for nuclear research CERN, Switzerland with (1.93%) publications. Publications on medical physics are spread over 24 languages. Medicine contributed the largest share (58.42%) publications among subjects, followed by physics and astronomy (57.17%) publications, engineering (18.26%), biochemistry, genetics and molecular biology (8.18%) and health professions (8.10%) publications.

Keywords: Medical physics, Scientometrics, Annual growth rate, Authorship pattern, Co authorship index and collaboration coefficient

1. Introduction

Education in the field of Medical Physics has experienced considerable growth and change from the time when the first publication of this report in 1993. Medical physics is one of the fastest emergent areas of research for academicians and physicists. It plays a vital role in the medical research areas of cancer, heart disease, and mental illness by involving in the development of new instrumentation and technology for use in diagnostic radiology. It is also concerned with the applications of digital computers in medicine and applications of information theory to diagnostic problems; processing, storing, and retrieving medical images; measuring the amount of radioactivity in the human body and studying the anatomical and temporal distribution of radioactive substances in the body.

Scientometrics is a discipline which analyses scientific publications to explore the structure and growth of science. They develop benchmarks to evaluate the quality of information

resources and packages of information for decision making in medical physics. It provides a key opportunity to the researcher to publish their articles with new strategies, innovations, new methods and new ideas Scientometric analysis is the quantitative study of a subject growth by using bibliometric indicators and statistical tools and techniques. It light a research on the pattern of growth of individual to the respective subject literature, inter-relationship among different branches of knowledge, productivity, authorship pattern, degree of collaboration, pattern of collection building, and their use. Gradually the Scientometric studies are attaining the status of inter-disciplinary in nature. The Scientometric techniques are used to understand the magnitude of the growth of a particular discipline. Especially the trends and pattern in growth, contribution of a particular author or institutions and the collaboration pattern, relative growth rate and so on. They empirically describe the constantly changing relationships in medical physics. This consequently sheds more light on our knowledge of the structure of subject of literature and better organization of information resources which can ultimately be effectively used. Therefore, the present study has been undertaken in order to know the growth and development of publications in the field of medical physics research as indexed in web of science database.

2. Objectives for the Study

The objective of the study was to perform a scientometric analyze the global research output in medical physics during 2000-2013, with a following aspect of the study:

- Forms of Publications
- Annual Growth Rate, Relative Growth Rate and Doubling Time of publications
- Authorship Pattern of Publications
- Relative citation impact of highly productive countries
- Highly productive institutes
- Highly preferred source titles for publication
- Language-wise distribution of cosmic rays research output

3. Methodology

The Web of Science database was used for retrieving data on medical physics during 2000-2013, using search terms namely ‘medical physics’ in ‘topic filed’. A total of 11181 publications were downloaded, the data were transferred to spread sheet application and analyzed the data as per objectives of the study.

4. Data analysis and interpretations

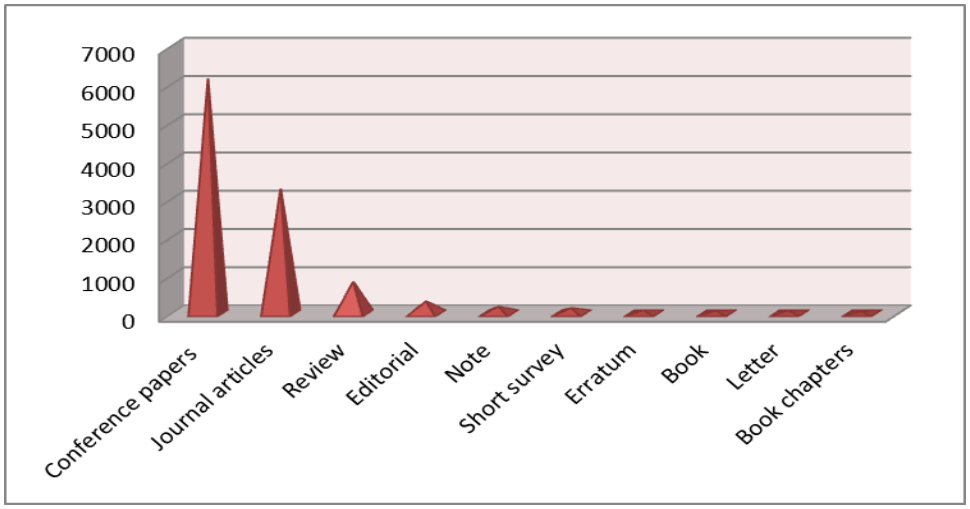
4.1 Forms of publications

Table 1 Forms of publications

S. No.	Forms of publications	No. of publications	Percentage
1	Conference papers	6161	55.10
2	Journal articles	3275	29.29
3	Review	835	7.47
4	Editorial	321	2.87

5	Note	179	1.60
6	Short survey	142	1.27
7	Erratum	81	0.72
8	Book	70	0.63
9	Letter	70	0.63
10	Book chapters	47	0.42
Total		**11181**	**100**

Figure 1 Form of publications



The table 1 reveals that the major source of publications covered by web of science databases on medical physics research is Conference papers with 6,161 publications (55.10%) followed by Journal articles with 3,275 publications (29.29%). Review ranks the third position with 835 publications (7.47%) followed by editorial with 321 publications (2.87%), note with 179 publications (1.60%), short survey with 142 publications (1.27%) and remaining forms are less than one percentage as seen in the table. The results indicate that the research outputs on the subject of the period covered by the study are mostly published in the form of conference papers.

4.2 Annual growth rate (AGR) of publications

Table 2 provides the AGR of the number of documents for period 2000 to 2013.

$$AGR = \frac{\text{End Value - First Value}}{\text{First Value}} \times 100$$

Table 2 AGR and CAGR of Publications 2000 - 2013

Year	No. of publications	Cumulative publications	Annual growth rate (AGR)	Compound annual growth rate (CAGR)
2000	233	233	-	-
2001	236	469	1.29	98.73
2002	282	751	19.49	63.19
2003	275	1026	-2.48	54.42
2004	349	1375	26.90	40.89
2005	442	1817	26.65	32.67
2006	515	2332	16.52	27.33
2007	617	2949	19.81	24.48
2008	828	3777	34.20	20.89
2009	1229	5006	48.43	16.71
2010	1448	6454	17.82	16.12
2011	639	7093	-55.87	24.19
2012	2562	9655	300.94	11.20
2013	1526	11181	-40.44	14.96

Figure 2 Growth rates of publications

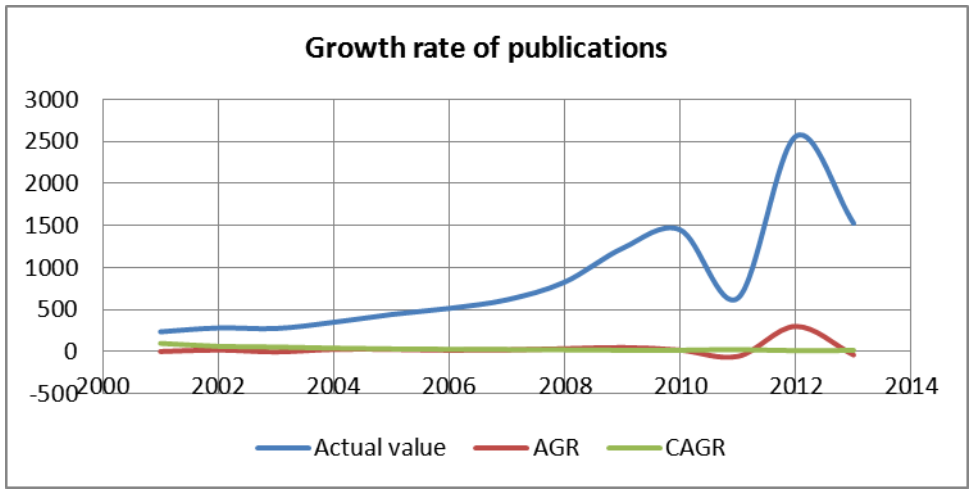


Table 2 reveals that during the period of 2000 to 2013, a total of 11181 publications were published on medical physics research. The highest number of publications is 2,562 published in 2012. The lowest publications of 233 are published in 2000. The average number of publications published per year was 798.64.

Table 2 also shows that the Annual growth rate of the total publications calculated year wise. It is seen in the table that there is a fluctuation trend of growth in the study period. The AGR has decreased -2.48 in 2003 and it was increased to 300.94 in 2012. Since then, there is fluctuation in year after year as illustrated in table 2. The reason for the fluctuation is that there is no constant growth of publications in every year.

4.2.1 Compound annual growth rate (CAGR)

The year-over-year growth rate of investment over a specified period of time. The compound annual growth rate is calculated by taking the nth root of the total percentage growth rate, where n is the number of years in the period being considered.

This can be written as follows:

$$CAGR = \left(\frac{\text{Ending Value}}{\text{Beginning Value}}\right)^{\left(\frac{1}{\#\text{ of years}}\right)} - 1$$

The compound annual growth rates of the publications are gradually decreased from 98.73 in 2001 to 11.20 in 2012 as seen in the Table 2. This indicates that though the yearly output is increasing year after year but the compound annual growth rate is in down ward trend.

4.3 Relative growth rate (RGR) and Doubling time (DT)

The Relative growth rate (RGR) is the increase in number of articles or pages per unit of time. This definition derived from the definition of relative growth rates in the study of growth analysis in the field of mobile technology. The mean relative growth rate (R) over the specific period of interval can be calculated from the following equation.

Relative growth rate (RGR)

$1 - 2R = \text{Log } W_2 - \text{Log } W_1 / T_2 - T_1$

Whereas

1-2 R- mean relative growth rate over the specific period of interval

$\text{Log}_e W_1$ - log of initial number of articles

$\text{Log}_e W_2$ - log of final number of articles after a specific period of interval

$T_2 - T_1$- the unit difference between the initial time and the final time

The year can be taken here as the unit of time.

Doubling Time (DT) = 0.693/R

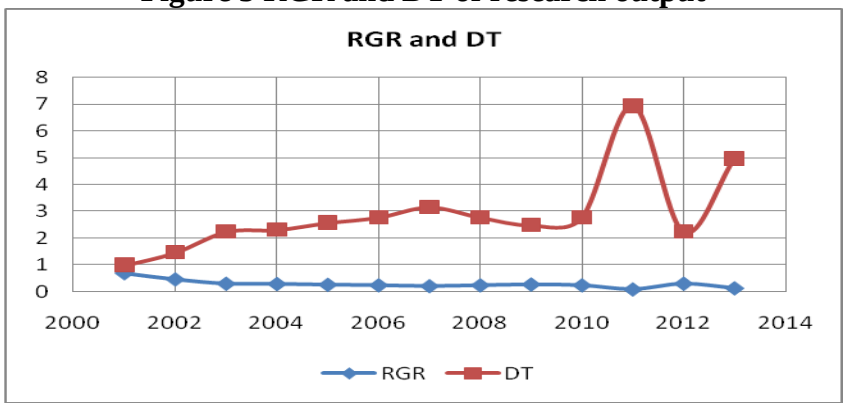
Table 3 Relative growth rate (RGR) and Doubling time (DT) of publications

Year	No. of Publications	Cumulative Total	W1	W2	RGR	DT
2000	233	-	-	5.45	-	-
2001	236	469	5.45	6.15	0.70	0.99
2002	282	751	6.15	6.62	0.47	1.47
2003	275	1026	6.62	6.93	0.31	2.24
2004	349	1375	6.93	7.23	0.30	2.31
2005	442	1817	7.23	7.50	0.27	2.57
2006	515	2332	7.50	7.75	0.25	2.77
2007	617	2949	7.75	7.99	0.22	3.15
2008	828	3777	7.99	8.24	0.25	2.77
2009	1229	5006	8.24	8.52	0.28	2.48
2010	1448	6454	8.52	8.77	0.25	2.77
2011	639	7093	8.77	8.87	0.10	6.93
2012	2562	9655	8.87	9.18	0.31	2.24
2013	1526	11181	9.18	9.32	0.14	4.95

The year wise RGR is found to be in the range of 0.70 to 0.14. Year wise calculation of RGR reveals that it has decreased from 2001 to 2007 and thereafter the trend is seen fluctuating (figure 3). The highest value corresponds to 2005, whereas the lowest value for the years 2013.

Doubling time too has a trend similar to that of RGR. Its ranges is from 0.99 to 6.93 (figure 3). A year wise increase is seen during the first seven year periods of the study, the DT has shown a year wise increase from 0.99 to 3.15 and thereafter a fluctuating.

Figure 3 RGR and DT of research output



4.4 Trend Analysis – Method of Least Squares

This is the best method for obtaining the trend values. It provides a convenient basis for obtaining the line of best fit in a series. Line of the best fit is a line from which the sum of the deviations of various points on its either side is zero. Further the sum of the squares of these deviations would be the least as compared to the sum of squares of the deviations obtained by using other lines.

The straight line trend has an equation of the type: $Y = a + bX$,

Where,

Y represents the estimated values of the trend, X represents the deviations in time period; 'a' and 'b' are constants.

The values of two constants 'a' and 'b' are estimated by solving the following two normal equations.

$$\sum Y = Na + b\sum X$$

$$\sum XY = a \sum X + b\sum X^2$$

Where N represents number of years for which data is given.

The variable X can be measured from any point of time as origin. To make calculation simpler, it is better to take the mid-point of time as the origin because the negative values of first half of the time series will equalize the positive values in the second half of the series which symbolically gives $\sum X = 0$.

When $\sum X = 0$, the two normal equations for finding the constants 'a' and 'b' will be

$$\sum Y = Na \Rightarrow a = \frac{\sum Y}{N} = Y$$

$$\sum XY = b \sum X^2 \Rightarrow b = \frac{\sum XY}{\sum X^2}$$

This provides that the constant 'a' is simply equal to the mean of Y values and the constant 'b' gives the rate of change. The constant 'a' refers to the Y intercept, i.e. the difference between the point of origin and the point where the trend line touches the Y axis. The constant 'b' refers to the slope of the line which indicates the change in Y for each unit change in X.

Table 4 Computation of Straight Line Trend by the Least Squares Method

Year	No. of Publications Actual (Y)	Deviation	Deviation	Multiply (X)	XY	X^2	No. of Publications Trend
2000	233	-6	-6.5	-13	-3029	169	-51.04
2001	236	-5	-5.5	-11	-2596	121	79.68
2002	282	-4	-4.5	-9	-2538	81	210.4
2003	275	-3	-3.5	-7	-1925	49	341.12
2004	349	-2	-2.5	-5	-1745	25	471.84
2005	442	-1	-1.5	-3	-1326	9	602.56
2006	515	0	-0.5	-1	-515	1	733.28
2007	617	1	1	1	617	1	864
2008	828	2	1.5	3	2484	9	994.72
2009	1229	3	2.5	5	6145	25	1125.44
2010	1448	4	3.5	7	10136	49	1256.16
2011	639	5	4.5	9	5751	81	1386.88
2012	2562	6	5.5	11	28182	121	1517.6
2013	1526	7	6.5	13	19838	169	1648.32
2014				15			1779.04
2015				17			1909.76

2016				19			2040.48
2017				21			2171.2
2018				23			2301.92
2019				25			2432.64
2020				27			2563.36
2021				29			2694.08
2022				31			2824.80
2023				33			2955.52
2024				35			3086.24
	11181				59479	910	60276.24

The equation of the straight line trend is Y= a + bX

Since $\sum X=0$, therefore

$$a = \frac{\sum Y}{N} = \frac{11181}{14} = 798.64$$

$$b = \frac{\sum XY}{\sum X2} = \frac{59479}{910} = 65.36$$

Thus substituting the value of ‘a’ and ‘b’ in the straight line of the trend, we get

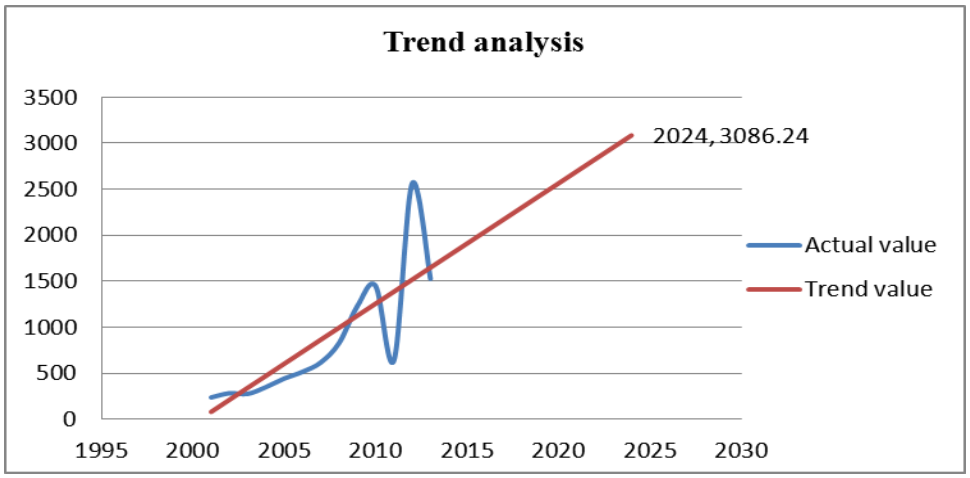
Y= a = bX => Y = 798.64 + 65.36x X

Estimate of 2024 will be calculated on the basis of X= 35

$Y_{2024} = 798.64 + 65.36 \times 35 = 3086.24$

Table 4 shows that the trend value of the total publications, calculated year wise which is increasing trend during the study period. The trend value has been increased from 341 in 2003 to 3086 in 2024. But the prediction of the trend made up to the year 2024 is also indicating the upward trend in the growth of literature. And this has been illustrated with the trend line and actual lines are presented in the Fig 4.

Figure 4 Trend of the medical physics literature



4.5 Authorship pattern of publications

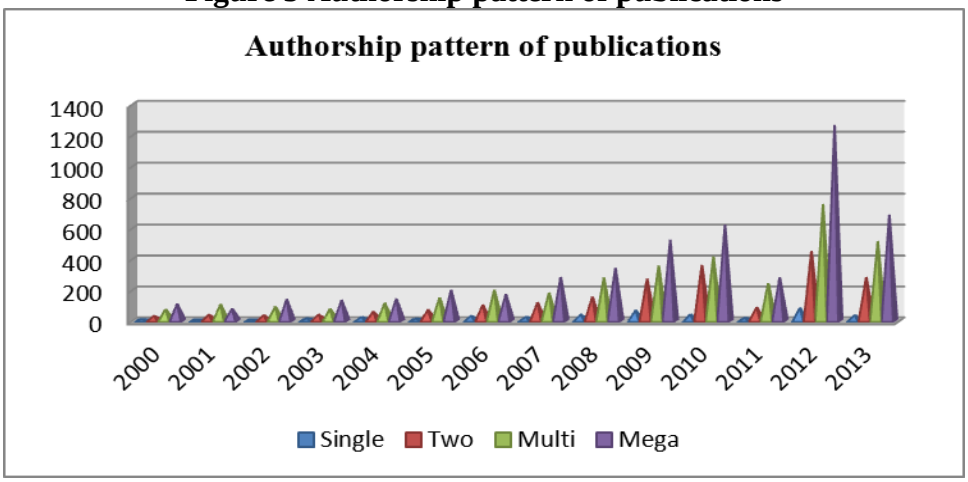
Table 5 Authorship pattern of publications

Block	Year	Single	CAI	Two	CAI	Multi	CAI	Mega	CAI	Total	CC
1	2000	12	98	33	83	76	92	112	113	233	0.65
	2001	7	57	41	103	108	129	80	80	236	0.65
	2002	9	61	37	78	94	94	142	118	282	0.66
	2003	18	125	42	91	79	81	136	116	275	0.63
	2004	26	142	61	104	117	95	145	98	349	0.63
	2005	16	69	73	98	151	96	202	108	442	0.66
	2006	34	126	105	121	202	111	174	80	515	0.62
Total		**122**		**392**		**827**		**991**			**0.64**
	2007	27	120	121	100	184	96	285	102	617	0.64
	2008	42	139	158	97	283	110	345	92	828	0.64
	2009	69	154	274	113	359	94	527	94	1229	0.62
	2010	43	81	363	127	417	92	625	95	1448	0.63

	2011	21	90	89	71	245	54	284	98	639	0.66
	2012	84	90	453	90	757	95	1268	109	2562	0.66
	2013	37	26	284	95	516	108	689	99	1526	0.67
Total		**323**		**1742**		**2761**		**4023**		**11181**	**0.65**

CAI–Co -Authorship index, CC–Collaboration coefficient

Figure 5 Authorship pattern of publications



The authorship pattern was analyzed to determine the percentage of single and multiple authors. From the table 5, it is observed that out of 11181 publications, maximum of 5014 (44.84%) publications have been contributed by mega authors, followed by multi authors with 3588 (32.09%) publications, two authors with 2134 (19.09%) publications. Only 445 (3.98%) publications have been contributed by single authors. It indicates that the multi authored works are more than that of single authored contributions in the field of medical physics.

4.5.1 Pattern of Co-Authorship Index (CAI)

For calculating the co-authorship index and collaboration coefficient for authors, countries have been replaced by block. For this study, the authors have been classified into two blocks, vz Single, Two, Multi and Mega authors and the results of Co-authorship index and collaboration coefficient have been presented in the Table 4. The study reveals that the result of co-authorship index and it is observed that the value of CAI for mega authored publications is the highest and for single authored publications was lowest, which indicated that the collaborative research is increasing in the field of medical physics. With regard to the multiple authored publications with more than multi authors, the co-authorship has shown fluctuation trend. This implies that the collaborative pattern in medical physics research is mainly characterized by co-authored papers not by single authored papers.

4.5.2 Collaboration Coefficient (CC)

The Collaboration Coefficient of authors by year-wise is shown in Table 4. The average value of collaboration coefficient for medical physics is 0.65. The highest value of collaboration coefficient is 0.67 in 2013 and lowest 0.62 in 2006 and 2009. However, the value of collaboration coefficient is showing increasing and decreasing trend in the two blocks year periods.

4.6 Authorship trend analysis

Table 6 Authorship trend analysis

Single Authors			Multiple Authors		Quantum of Research Output	Degree of Collaboration
Year	**Quantum of Output**	**Percentage**	**Quantum of Output**	**Percentage**		
2000	12	0.11	221	1.98	233	0.95
2001	7	0.06	229	2.05	236	0.97
2002	9	0.08	273	2.44	282	0.97
2003	18	0.16	257	2.30	275	0.93
2004	26	0.23	323	2.89	349	0.93
2005	16	0.14	426	3.81	442	0.96
2006	34	0.30	481	4.30	515	0.93
2007	27	0.24	590	5.28	617	0.96
2008	42	0.38	786	7.03	828	0.95
2009	69	0.62	1160	10.37	1229	0.94
2010	43	0.38	1405	12.57	1448	0.97
2011	21	0.19	618	5.53	639	0.97
2012	84	0.75	2478	22.16	2562	0.97
2013	37	0.33	1489	13.32	1526	0.98
Total	**445**	**3.97**	**10736**	**96.03**	**11181**	**0.96**

Figure 6 Authorship trend analysis

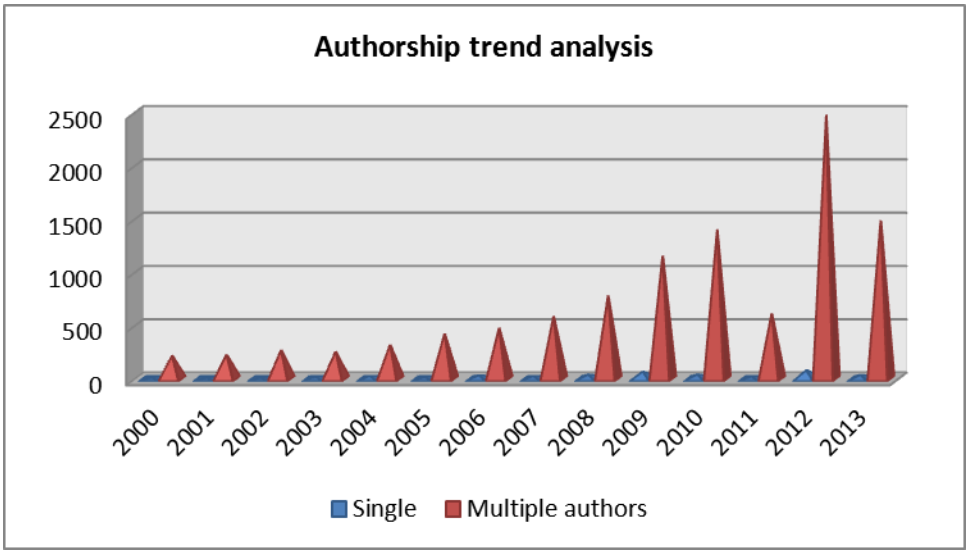


Table 6 presents the single and multiple authors' productivity pattern on yearly basis. A careful examination of the table reveals that the productivity patterns on the medical physics are much contributed by the multiple authors than the single author since 2000 to 2013. Thus, from this analysis it can be interpreted that basically the medical physics research is much dominated by multiple authors.

4.6.1 Degree of Collaboration

The Degree of collaboration of authors by year wise has been calculated for the years 2000 to 2013 is shown in table 5. The year wise Degree of collaboration falls between 0.93 and 0.98. The Degree of collaboration of publications of the medical physics is 0.96. This brings out clearly the prevalence of team research in this field. Out of the total publications 96.03% of contributions were collaborated with multi authorship and 3.97% of contributions were collaboration with single authors.

4.7 Identification of Most Prolific Authors

Table 7 Identification of Most Prolific Authors

Rank	Author	Institutes	No. of publications	Percentage
1	Hendee, W R	Medical college Wisconsin, USA	57	0.51
2	Levin, C S	Stanford university school of medicine, USA	52	0.47
3	Yanagida, T	University of Tokyo, Japan	51	0.46

4	Yamaya, T	National institute of radiological sciences, Japan	50	0.45
5	Yoshida, E	National institute of advanced industrial science and technology, Japan	44	0.39
6	Fujimoto, Y	Hiroshima University, Japan	39	0.35
7	Pia, M G	Istituto Nazionale Di Fisica Nucleare, Italy	38	0.34
8	Yoshikawa, A	Kyushu University, Japan	36	0.32
9	Nishikido, F	National institute of radiological sciences, Japan	36	0.32
10	Piemonte, C	Fondazione bruno kessler, Italy	34	0.30
11	Tashima, H	National institute of radiological sciences, Japan	34	0.30
12	Llosa, G	Instituto de Fisica Corpuscular, Spain	32	0.29
13	Fiorini, C	Université de versailles saint-quentin, France	31	0.28

Table 7 presents the rank list the authors who have contributed more than 200 articles or more are taken into account to avoid a long list. Most of the authors from Japan and USA, hence, it can be interpreted that the medical physics research has been dominated by the Japan and USA researchers. It reveals that Hendee, W R, Medical college Wisconsin, USA is the most productive author contributing 57 articles followed by Levin, C S, Stanford university school of medicine, USA with 52 articles and Yanagida, T, University of Tokyo, Japan with 51 articles, Yamaya, T, National institute of radiological sciences, Japan with 50 articles, Yoshida, E, National institute of advanced industrial science and technology, Japan with 44 articles, Fujimoto, Y, Hiroshima University, Japan with 39 articles and Pia, M G, Istituto Nazionale Di Fisica Nucleare, Italy with 38 articles respectively. And a total of 2379 authors are contributed entire research output of the period under study.

4.8 Highly productive institutes

Table 8 Highly productive institutes

Rank	Institutions	Country	No. of publications (%)
1	Istituto Nazionale Di Fisica Nucleare	Italy	330 (2.95%)
2	European organization for nuclear research CERN	Switzerland	216 (1.93%)
3	Tsinghua university	China	145 (1.30%)

4	National institute of radiological sciences	Japan	122 (1.09%)
5	University Michigan	USA	117 (1.05%)
6	University of Texas M D Anderson cancer center	USA	109 (0.97%)
7	Tohoku university	Japan	105 (0.94%)
8	Politecnico di Milano	Italy	101 (0.90%)

Table 8 shows the institutes that have contributed 100 or more publications on medical physics research during 2004-2013. Findings revealed that Istituto nazionale di fisica nucleare, Frascati, Italy with 330 (2.95%) publications is the most productive institutions in the field of medical physics research followed by European organization for nuclear research CERN, Switzerland with 216 (1.93%) publications, Tsinghua university, China with 145 (1.30%) publications, National institute of radiological sciences, Japan with 122 (1.09%) publications, University of Michigan, USA with 117 (1.05%) publications, University of Texas M D Anderson cancer center, USA with 109 (0.97%) publications, Tohoku university, Japan with 105 (0.94%) publications and Politecnico di Milano, USA with 105 (0.90%) publications.

4.8 Highly productive countries

Table 9 Highly productive countries

Rank	Country	Total publications (%)	Rank	Country	Total publications (%)
1	USA	3626 (32.43%)	11	South Korea	265 (2.37%)
2	Germany	1181 (10.56%)	12	Australia	239 (2.14%)
3	Japan	1027 (9.19%)	13	Netherlands	225 (2.01%)
4	UK	865 (7.74%)	14	Russia	191 (1.71%)
5	Italy	835 (7.47%)	15	Brazil	169 (1.51%)
6	China	571 (5.11%)	16	Poland	169 (1.51%)
7	France	548 (4.90%)	17	India	161 (1.44%)
8	Switzerland	436 (3.90%)	18	Austria	152 (1.36%)
9	Canada	397 (3.55%)	19	Sweden	150 (1.34%)
10	Spain	327 (2.92%)	20	Taiwan	105 (0.94%)

In all, there were 108 countries involved in research in medical physics, which published at least one publication. The USA topped the list with highest share (32.43%) of publications. Germany ranked second with 10.56% share of publications followed by Japan with 9.19% share of publications, UK with 7.74% share of publications, Italy with 7.47% share of publications, China with 5.11% share of publications, France with 4.90% share of publications, Switzerland with 3.90% Canada with 3.55% share of publications and the remaining countries are publishing less than 3% of the research output in this study period. The publication share of highly productive countries (≥100 publications) on medical physics is given in table 9.

4.9 Language wise distributions

Publications on medical physics are spread over 24 languages. The maximum number of publications have been published in English language with 10807 publications (96.66%), followed by German with 97 publications (0.87%), Chinese ranks third position with 63 publications (0.56%), French with 47 publications (0.42%), Japanese with 43 publications (0.38%) and Spanish with 41 publications (0.37%). And the remaining languages such as Polish, Russian, Portuguese, Italian and other languages are constituted in negligible percentage. The English language superiority was found in every year in total productivity on the subject during the study period.

4.10 Most preferred source titles

The conference publications and scientific journals are most important medium of communication in scientific field. To determine the most scientific journals and conference publications in this field, preferred source are identified by the researchers for their publications.

Table 10 Source title of publications

Rank	Source title	Country	No. of publications	Impact factor
1	IEEE Nuclear science symposium Conference proceedings	USA	3755	-
2	IFMBE proceedings	Germany	711	-
3	AIP conference proceedings	USA	461	-
4	Physics in medicine and biology	UK	424	2.761
5	Health physics	USA	422	1.271
6	Medical physics	USA	262	2.635
7	Radiological physics and technology	Japan	178	-
8	Proceedings of SPIE the International society for optical engineering	USA	151	0.20
9	Nuclear instruments and methods in physics research section A accelerators spectrometers detectors and associated equipment	USA	138	1.216
10	Applied physics letters	USA	138	3.515

The scientific literature on medical physics is spread over 1324 different source journals. The rank list of top 10 source titles with impact factor is listed in the table 10. It reveals that IEEE Nuclear science symposium conference proceedings, USA tops the list with the highest number of publications 3755 (33.58%), followed by IFMBE proceedings, Germany with a share of 1270 (6.36%) publications. AIP conference proceedings, USA occupy the third position with 461 (4.12%) publications. The fourth highest source title is Physics in medicine and biology, UK

with 424 (3.79%) publications and the impact factor is 2.761 and Health physics, USA with 422 (3.77%) and the impact factor is 1.271 and Medical physics, USA with 262 (2.34%) publications and the impact factor is 2.635.

4.11 High productivity subject areas

Table 11 High productivity subject areas

Rank	Subject	No. of articles	Percentage
1	Medicine	6532	58.42
2	Physics and astronomy	6392	57.17
3	Engineering	2042	18.26
4	Biochemistry, genetics and molecular biology	915	8.18
5	Health professions	906	8.10
6	Chemical engineering	883	7.90
7	Computer science	560	5.01
8	Environmental Science	486	4.35
9	Materials science	370	3.31
10	Pharmacology, toxicology and pharmaceutics	302	2.70

Figure 7 High productivity subjects

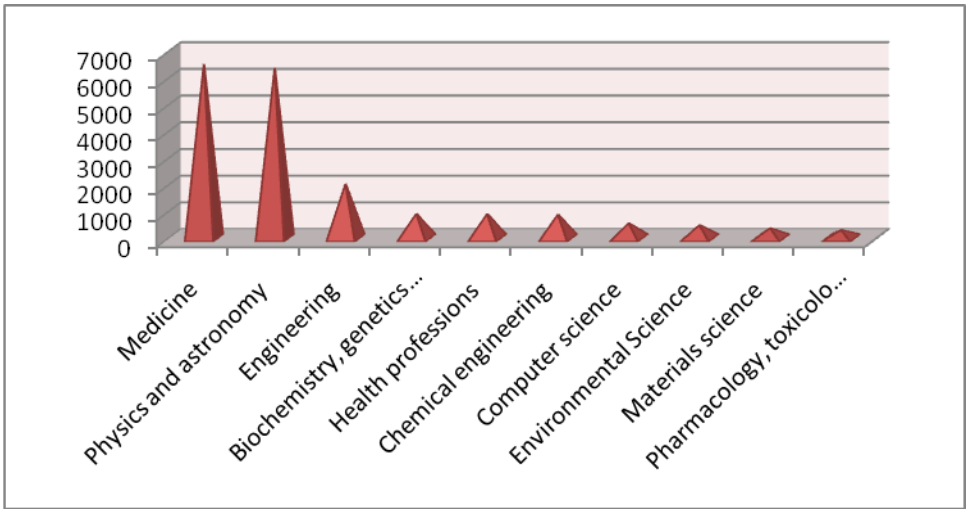


Table 11 shows high productivity subjects which are contributing more than 300 articles. It is found that Medicine has highest number of articles with 6532 (58.42%) followed by Physics and astronomy contributing 6392 (57.17%) articles. Engineering occupy the third position with 2042 (18.26%) articles. The fourth highest articles belonged to the subject Biochemistry, genetics and molecular biology with 915 (8.18%), health professions with 906 (8.10%) and chemical engineering with 883 (7.90%) articles respectively.

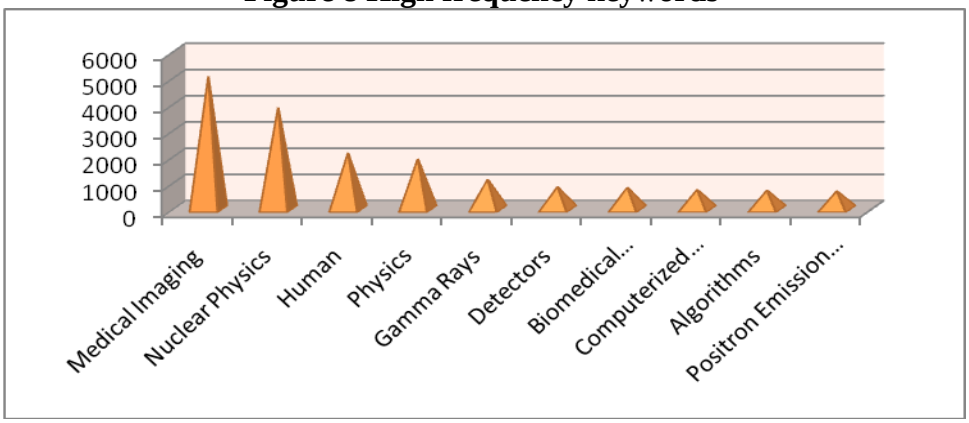
4.12 Keyword analysis

Keywords are one of the best Scientometric indicators to understand and grasp instantaneously the thought content of the publications and to find out the growth of the subject field. By Analysing the keywords appeared either in the title or assigned by the indexer or the author himself will facilitate knowing in which direction the knowledge goes.

Table 12 Keyword analysis

Rank	Subject	No. of articles	Percentage
1	Medical imaging	5071	45.35
2	Nuclear physics	3880	34.70
3	Human	2151	19.24
4	Physics	1918	17.15
5	Gamma rays	1136	10.16
6	Detectors	849	7.59
7	Biomedical engineering	825	7.38
8	Computerized tomography	741	6.63
9	Algorithms	716	6.40
10	Positron emission tomography	686	6.14

Figure 8 High frequency keywords



The keywords appeared in the Index Keywords field in web of science database of medical physics publications were analysed. Table 12 lists the high frequency keywords. The highly cited keywords were: Medical imaging with 5071 (45.35%) publications, nuclear physics with 3880 (34.70%) publications, human with 2151 (19.24%) publications, physics with 1918 (17.15%) publication and gamma rays with 1136 (10.16%) publications respectively.

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5 Conclusions

Medical physics plays a very predominant role in healthcare specialties such as diagnostic and intervention radiology, nuclear medicine, and radiation oncology. A lot of research is being carried out all over the world in this field. A total of 11181 publications was published in medical physics during 2000-2013. The single most prevalent form of publications is the conference papers, in which 55.51% of the total literature is published. The highest number of publications 2,562 (22.91%) were published in 2012. The average number of publications published per year was 798.64. The year wise RGR is found to be in the range of 0.70 to 0.14. The trend value has been increased from 341 in 2003 to 3086 in 2024. Out of 11181 publications, maximum of 5014 (44.84%) publications have been contributed by mega authors. The value of the Co Authorship Index is increasing and decreasing trend in the two block year periods. The highest value of Collaboration Coefficient is 0.67 in 2013 and the average value of Collaboration Coefficient for medical physics is 0.65. The Degree of collaboration of publications of the medical physics is 0.96. Hendee, W R, Medical college Wisconsin, USA is the most productive author contributing 57 articles followed by Levin, C, S, Stanford university school of medicine, USA with 52 articles. Most of the authors from USA, hence, it can be interpreted that the medical physics research has been dominated by the USA researchers. USA topped the list with highest share (32.43%) of publications. Germany ranked second with 10.56% share of publications followed by Japan with 9.19% share of publications and UK with 7.74% share of publications. Istituto nazionale DI fisica nucleare, Frascati, Italy with 330 (2.95%) publications is the most productive institutions in the field of medical physics research followed by the European organization for nuclear research CERN, Switzerland with 216 (1.93%) publications. IEEE Nuclear science symposium, conference proceedings, USA tops the list with the highest number of publications 3755 (33.58%), followed by IFMBE proceedings, Germany with a share of 1270 (6.36%) publications. Medicine has the highest number of articles with 6532 (58.42%) followed by Physics and astronomy contributing 6392 (57.17%) articles. The highly cited keywords were: Medical imaging with 5071 (45.35%) publications, nuclear physics with 3880 (34.70%) publications, human with 2151 (19.24%) publications, physics with 1918 (17.15%) publications. The study revealed that the medical physics related publications seem to be popular among the national and international research community.

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Brief Biography

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